Algorithm for the Management of Endoscopic Perforations: A Quality Improvement Project

Lukasz Kowalczyk, MD[1], Chris E. Forsmark, MD[1], Kfir Ben-David, MD[2], Mihir S. Wagh, MD[1], Shailendra Chauhan, MD[1], Dennis Collins, MD[1] and Peter V. Draganov, MD[1]

Perforations are an uncommon but serious complication of endoscopy. Although they are well recognized, no universally accepted strategy for their management exists. The need for management algorithms in situations that call for multiple interventions in a short time, with coordinated effort encompassing multiple providers from different specialties, has long been recognized, but no such clinical care pathway has been developed for the management of endoscopic perforations. Since perforations are uncommon, a predetermined plan of action can streamline patient management. Furthermore, such a plan demonstrates preparedness on the part of the gastroenterologist. We developed an endoscopic perforation management strategy based on the best available scientific evidence and our specific resources. We report our experience in the hope that it may form a useful framework for gastroenterologists attempting to do the same at their own institution.

Am J Gastroenterol 2011;106:1022–1027; doi:10.1038/ajg.2010.434

"We don't plan to fail; we just fail to plan."
—Unknown

Introduction

Perforations of the gastrointestinal (GI) lumen are relatively uncommon but are considered one of the most serious complications of endoscopy. Although perforations are well recognized as possible adverse events, there is no universally accepted strategy for their management. Traditionally, perforations have been managed surgically. However, improved endoscopic visualization and devices have permitted nonsurgical management in selected cases. The clinical approach, at the time a perforation is identified, is further complicated by the need to involve multiple specialty providers and reach consensus to accomplish a number of tasks and interventions in a short time. As such, a management strategy that focuses on only the final point (e.g., a surgical versus a conservative approach) can often be suboptimal. Before this final end point is reached, multiple steps have to occur that require dynamic coordination among multiple services, including endoscopy, surgery, and radiology. The need for management algorithms in situations that call for multiple urgent interventions by multiple providers from different specialties has been recognized, and such algorithms have been used in various areas of medicine (e.g., management of cardiorespiratory arrest) (1,2). The goal of improving the quality and safety of care has become a dominant theme in recent times, and complex conditions are particularly prone to lapses in communication, quality, and safety.

As part of our ongoing commitment to improved patient care in our institution, we have quarterly quality improvement (QI) meetings. During these meetings we review guidelines, discuss specific cases in which adverse events have occurred, and attempt to establish a consensus approach for management of specific clinical scenarios. As a result of these QI meetings, it became apparent that there were multiple, opposing opinions regarding the utility and timing of specific diagnostic and therapeutic interventions that may take place after suspected or established perforations. Specifically, there was a significant degree of variability regarding the following questions:

- Should the extent of the perforation be endoscopically evaluated and the perforation endoscopically repaired if possible, or should the endoscopist suction all the air and promptly withdraw the endoscope?
- Should a nasogastric tube be placed? When should this occur—during the endoscopic procedure, after the procedure in the recovery area, or at a later time after other evaluation has taken place?
- Is there a need to obtain blood work for evaluation? If so, what specific blood tests should be ordered, and when?
- Is there a need to obtain a radiographic study to confirm the perforation even if there is no doubt that a perforation has occurred (e.g., the endoscope entered the peritoneal cavity)?

[1]Division of Gastroenterology, Hepatology, and Nutrition, University of Florida, Gainesville, Florida, USA; [2]Department of Surgery, University of Florida, Gainesville, Florida, USA. **Correspondence**: Peter V. Draganov, MD, University of Florida, Division of Gastroenterology, Hepatology and Nutrition, Room HD 602, PO Box 100214, Gainesville, Florida 32610-0214, USA. E-mail: dragapv@medicine.ufl.edu

Table 1. Perforations over 10 years

Demographics			
Sex			
Female	24		
Male	21		
Age (y)			
Mean	64		
Range	20–94		
Perforations by procedure	**No. of procedures**	**No. of perforations**	**Percentage**
Colonoscopy	16,395	12	0.08
Esophagogastroduodenoscopy	23,877	15	0.07
Endoscopic retrograde cholangiopancreatography	5,951	9	0.17
Endoscopic ultrasound	5,029	8	0.16
Flexible sigmoidoscopy	1,936	1	0.05
Perforations by site	**No. of perforations per site**	**Percentage**	
Esophagus	6	13.33	
Gastric	6	13.33	
Duodenum	19	42.22	
Colon	12	26.66	
Rectum	1	2.22	
Biliary	1	2.22	
Outcome	**Total**	**Percentage**	
Complete recovery	34	75.55	
Partial recovery	8	17.77	
Death	3	6.66	

- If radiologic studies are required, what is the preferred diagnostic modality—plain flat-view film, acute abdominal series including flat upright film, or computed tomography (CT)?
- If CT is to be ordered, should one order the study with intravenous contrast, oral contrast, both, or neither? If oral contrast is given, how long before the study should it be administered?
- Should an antibiotic be given? If so, when, and which antibiotic?
- Should a routine electrocardiogram be obtained?
- Should a surgical consultation be obtained if the perforation is closed endoscopically?
- If it is deemed necessary, what is the best timing of the surgical consultation—immediately when the perforation is recognized, or after some supportive evidence, such as radiologic study, is available—and which surgical specialty should be consulted?
- To which service should the patient be admitted—surgical or medical?

Although there were many areas of uncertainty, and even totally opposing opinions, there was a unanimous consensus that GI perforation is a very serious and potentially life-threatening adverse event that occurs infrequently and requires a multidisciplinary approach. It seemed clear that we had an opportunity to improve our processes. Hence, we decided to develop an endoscopic perforation management strategy based on the best available scientific evidence and the specific resources of our institution. The process was relatively complex, and we decided to report our experiences in the hope that they might form a useful framework for gastroenterologists attempting to do the same thing at their own hospital or clinic.

The process

Approval for this project was obtained from the Institutional Review Board at the University of Florida.

We reviewed 10 years (from 2000 to 2010) of our perforation record using our electronic procedure report–generating system and our prospectively maintained, electronically searchable adverse-event database. As a routine procedure in our endoscopic unit, the patients are assessed for potential complications during their recovery stay. The following day, an attempt is made to contact all patients by telephone to detect any delayed complications. Any complication that is detected is recorded in our electronic complication database. During this time period, we performed 53,188 endoscopic procedures. We identified 45 perforations that occurred during this time period (**Table 1**).

A MEDLINE literature review on endoscopic perforation was performed. Papers pertaining to the frequency of perforation, diagnosis, and management were identified and reviewed. The references of these papers were further manually reviewed to identify articles not identified by the electronic search.

During our quarterly QI conference, we discussed our perforation record of the past 10 years with all fellows and faculty. In addition, we presented our data from the literature search. Finally, we allowed significant time for discussion and exchange of ideas.

Based on the review of our own perforation record, review of the literature, and ideas brought forward at our QI conference, we created a preliminary perforation management algorithm. This was discussed and amended by a core of physicians who have a specific interest in therapeutic endoscopy.

Input from gastroenterology department. The preliminary algorithm was presented at our next QI meeting, and a number of additional issues were brought up by this larger group.

The effort of managing a perforation, including the coordination of radiologic and surgical support, interfered with the ability of the endoscopist to efficiently continue elective procedures, which would subsequently be placed on hold, creating a major disruption in the flow of patients through the endoscopy unit and resulting in frustrated and dissatisfied patients and families. Therefore, we added the provision that a backup faculty member assume the care of the remaining patients to permit the endoscopist involved with the perforation to focus solely on managing that patient.

Extensive literature on improving communication among health-care providers was reviewed, and the need for effective communication among various providers was emphasized (3–6). Hence, it was decided that attending physicians should communicate directly with one another regarding the perforation, rather than via physicians in training.

Frequently, GI fellows and faculty and endoscopy nurses all communicate with the family. Although the overall message is usually the same, some discrepancy may occur owing to use of different terminology. Therefore, it was agreed that a single person should be designated by the GI attending to communicate with the family and relatives—preferably, that person should be the GI attending him- or herself.

The antibiotics stocked in our endoscopy unit were tailored to the treatment or prophylaxis of cholangitis, prophylaxis of wound infection after percutaneous gastrostomy placement, prophylaxis of pancreatic cyst infection, and prophylaxis of endocarditis. We learned we did not stock the antibiotics that are typically used after GI tract perforation. Our system was for the physician involved to orally request the antibiotic. If it was not available in our endoscopy unit (which was usually the case), a written order had to be generated and faxed to the pharmacy. Subsequently, the medication(s) had to be delivered to our unit from the pharmacy to be given to the patient. Hence, we agreed to use the combination of ciprofloxacin and metronidazole as a first-line therapy and Timentin (ticarcillin combined with clavulanate) if the patient was allergic to the first-line medications. The medications are to be given by intravenous infusion as soon as the perforation is recognized or suspected, preferably during the endoscopic procedure. Consequently, we changed the formulary for our endoscopy unit and now routinely stock these medications and have them immediately available. Finally, if perforation is detected during endoscopy, the endoscopist should immediately change from room air to carbon dioxide (if available) for insufflations.

After we incorporated the input from GI faculty and fellows as well as endoscopy nurses, an updated algorithm was created.

Input from radiology department. Radiologic testing after GI perforation was discussed with our radiology colleagues, and the following issues were addressed.

We reached a consensus that plain abdominal or chest films are suboptimal and that a CT scan without intravenous contrast but with oral or rectal water-soluble contrast is the preferred test for upper GI or lower GI perforations, respectively. The main arguments favoring CT over plain films were the following: (i) CT is superior in detecting small retroperitoneal or mediastinal perforations; (ii) if endoscopic closure of the perforation is carried out during the index endoscopic procedure, CT with luminal contrast can evaluate the adequacy of the closure (e.g., whether there is extravasation of contrast); and (iii) coexisting pathology such as small pneumothorax can be better detected by CT, and this has direct therapeutic implications.

We also agreed that for esophageal, gastric, and duodenal perforations, oral contrast should be given immediately before the CT scan in the radiology department. The contrast should be administered by mouth for esophageal perforations, and by nasogastric tube for gastric and duodenal perforations. In all cases, the contrast should be given in the radiology department immediately before the CT rather than according to standard CT protocol, which requires the patient to drink oral contrast in three separate doses starting 1 hour before the imaging.

If a duodenal perforation is suspected, the patient should be positioned in right lateral position to allow pooling of contrast in the duodenum.

There was a consensus that intravenous contrast would not significantly enhance the diagnostic value of the CT, specifically in the setting of an acute perforation, and therefore should be avoided in an attempt to decrease potential complications (e.g., renal toxicity). This is particularly important as these patients might need follow-up intravenous-contrast-enhanced CT to evaluate for abscess formation.

The need to clearly communicate the indication for the CT to the radiology service was identified, given that this indication and protocol differ from standard abdominal CT indications, as described above. The number at which to directly call the radiology attending was posted on the perforation management flow chart to make it immediately available and easy to identify.

Input from surgery department. The next step in creating our algorithm was to discuss it with the surgical faculty. A few important points were identified.

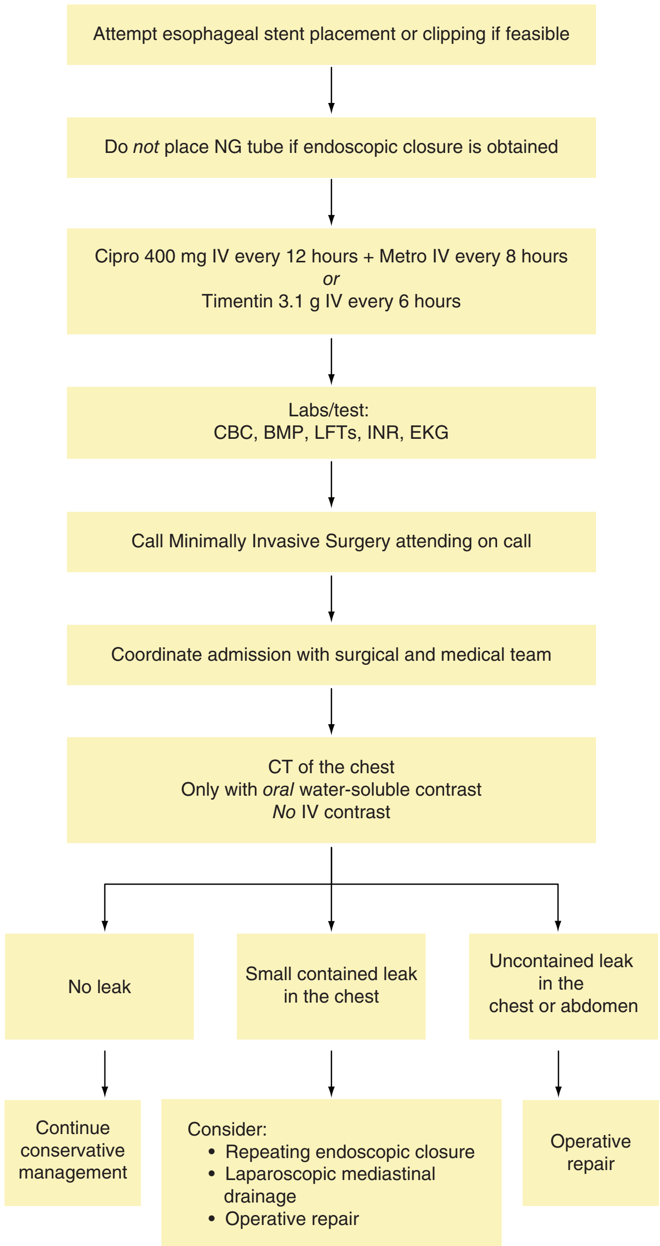

Figure 1. Esophageal perforation. BMP, basic metabolic panel; CBC, complete blood count; Cipro, ciprofloxacin; CT, computed tomography; EKG, electrocardiogram; INR, international normalized ratio; IV, intravenous; LFTs, liver function tests; Metro, metronidazole; NG, nasogastric.

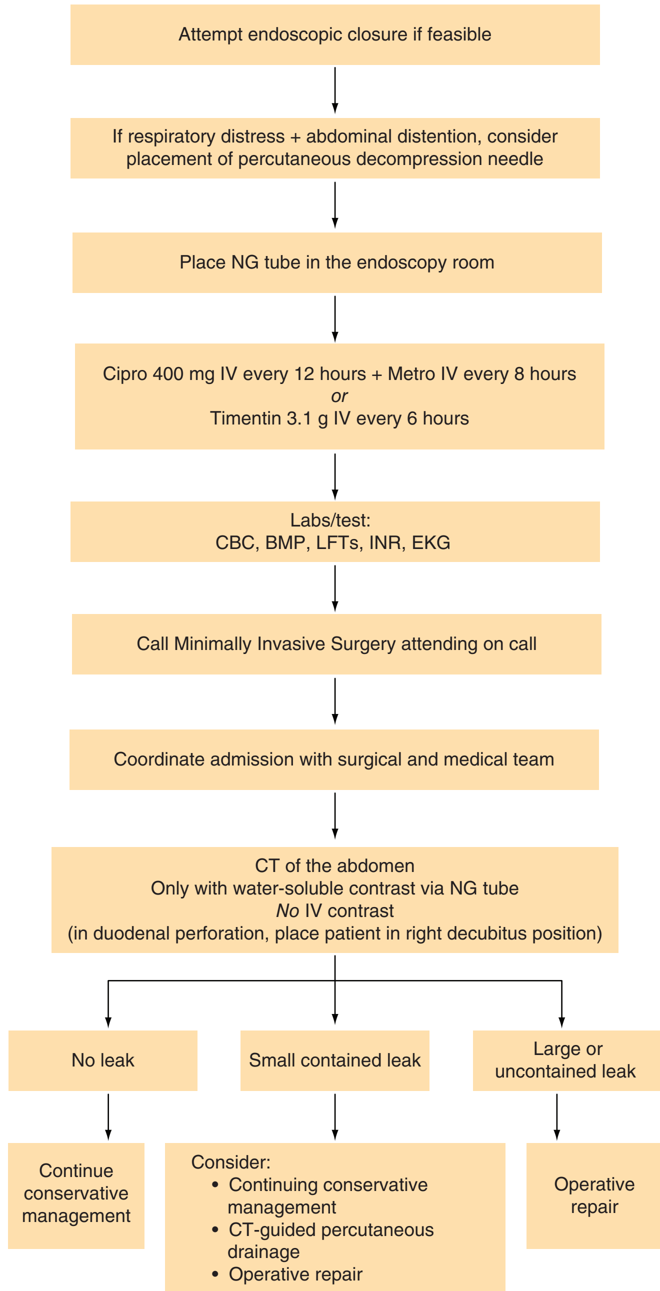

Figure 2. Gastric, duodenal, or small-bowel perforation. BMP, basic metabolic panel; CBC, complete blood count; Cipro, ciprofloxacin; CT, computed tomography; EKG, electrocardiogram; INR, international normalized ratio; IV, intravenous; LFTs, liver function tests; Metro, metronidazole; NG, nasogastric.

First, our surgical colleagues preferred to be involved early once the perforation was identified or highly suspected, rather than waiting until all the tests that might further clarify the patient's condition were obtained.

It was agreed that direct communication between attending physicians is preferred, rather than the standard communication approach used for routine consultations.

It was emphasized that significant peritoneal, retroperitoneal, or mediastinal air may be seen on CT if endoscopic closure is attempted. The presence of the air does not reflect the success or failure of endoscopic closure or the size of the perforation. Rather, it usually is the result of the additional air insufflated during the attempt at endoscopic closure. This should not serve as the indication for surgical intervention.

We also discussed the specific criteria for when to consider surgery. In general, if endoscopic closure is attempted with a stent or clips and the CT imaging with intraluminal contrast does not show extravasation, medical management is the preferred approach. If there is a small, contained extravasation, the therapeutic options include medical management, radiologic placement of percutaneous drains in the area of extravasation, and surgery, and the decision needs to be made on a case-by-case basis. In case of overt extravasation of contrast, minimally invasive surgical options should be given first consideration.

Traditionally, in our institution, all perforation consultations are referred to the Acute Care Surgery service, which takes care of all emergent consultations in our hospital. The service consists of surgeons with expertise in general surgery and has a strong focus on trauma management. In our case, a consensus was reached that a consultation with the Minimally Invasive Surgery service should be requested directly for any upper GI perforation, including esophagus, stomach, duodenum, and small bowel. For colonic perforations, the Colorectal Surgery service should be involved.

Final algorithm. Owing to site-specific differences, three flowcharts were created specifically pertaining to esophageal, gastroduodenal, and colonic perforations (**Figures 1–3**). On each flowchart, the specific steps and their timing were outlined, and the appropriate telephone and pager numbers of all parties involved were listed (to protect privacy, the telephone and pager numbers are not listed in the figures). Based on all the input described above, a final algorithm was established and then distributed to all parties involved for their final approval.

The new perforation management algorithm was implemented and posted in our endoscopy unit. Since that time, we have had five suspected GI perforations that led to the activation of the pathway. In two cases, perforation was not verified on the imaging obtained as defined in our algorithm. In three cases, perforation was verified. One of these patients had pancreatic cancer with peritoneal carcinomatosis and suffered perforation at the time of colonoscopy done for severe obstipation and high fecal impaction. This patient required laparotomy, and the perforation was successfully closed at the time of surgery. The following day, in accordance with patient and family wishes, supportive care was withdrawn and the patient died. Another patient had a periampullary perforation related to endoscopic retrograde cholangiopancreatography and sphincterotomy. This patient was managed without surgery according to the algorithm and fully recovered with conservative management. Finally, the third patient had esophageal perforation after dilation of a refractory esophageal stricture. A fully coved esophageal stent was placed in the same session, and follow-up imaging showed no extravasation of oral contrast.

Importantly, in all cases, a high degree of satisfaction was expressed by all medical staff involved—gastroenterologist, endoscopy nurses, radiologist, and surgeons—regarding the structured coordinated approach. Patient management proceeded in an organized manner as compared with previous experiences. A disorganized and relatively stressful experience has become better organized with clearly assigned responsibilities, resulting in a less stressful environment and more efficient completion of necessary tasks.

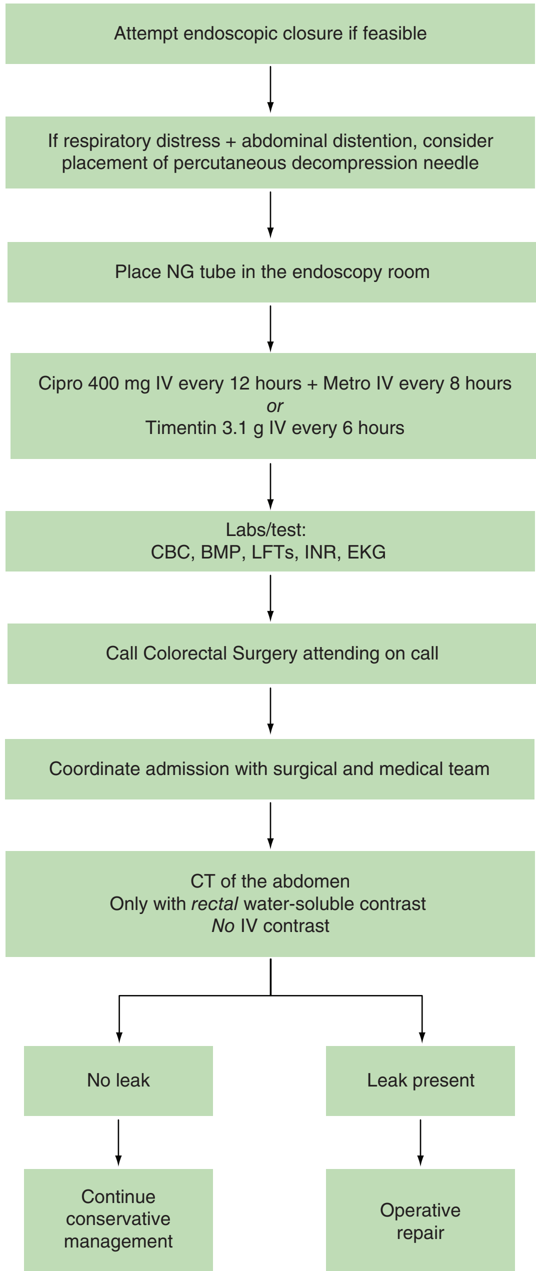

Figure 3. Colonic perforation. BMP, basic metabolic panel; CBC, complete blood count; Cipro, ciprofloxacin; CT, computed tomography; EKG, electrocardiogram; INR, international normalized ratio; IV, intravenous; LFTs, liver function tests; Metro, metronidazole; NG, nasogastric.

Discussion

Perforations during GI endoscopy are uncommon but predictable events and can be associated with significant morbidity and mortality. Ample literature exists that details the prevalence of perforations in various parts of the GI tract. Furthermore, over the past decade, a number of alternatives to surgical repair have been described. No direct comparison among the various management options in the form of randomized controlled trials exists. Most importantly, the focus of the published literature is on the final management point (e.g., surgical versus endoscopic closure). Unfortunately, very little attention has been paid to how to practically manage patients through the occurrence of the perforation to recovery. The early time period immediately following the discovery (or suspicion) of the perforation is particularly stressful to all involved, because multiple interventions need to be carried out in a short time by multiple providers from different medical specialties. We strongly believe that a coordinated "first-response" management algorithm is essential to improve the management of these patients and, hopefully, the final outcome. We designed and implemented an algorithm for the management of GI perforations in our hospital based on the best available evidence from the literature and incorporating the locally available resources. Specific attention was paid to the timing of various interventions and to the coordination of communication and care among various providers.

The structure of our endoscopy unit represents a type of team referred to in the professional literature as an "action team." It is characteristic of such a team that members possess a high level of specialization, it focuses on completing a specific task, membership changes dynamically, collaboration occurs for short periods of time, and different professional cultures must integrate (attending physicians, fellows, nurses, and technicians, among others). With this type of team the ability to coordinate and to adapt to new situations is key to achieving appropriate outcomes (7,8).

Patient-safety literature supports the notion of teamwork, and open communication promotes the delivery of quality care. Surveys of health-care providers show that they rate teamwork and communication as essential to high-quality care (9). Additionally, retrospective analyses of incident reports and adverse events identify inadequate teamwork and communication as the primary factors contributing to error (10). In light of such data, the Joint Commission report on safety documented that many medical errors result from miscommunication and that the institution of safeguards, such as handoffs and an environment conducive to professional communication, is required to minimize error (11). This issue has also been specifically addressed in the GI literature, in which communication has been identified as a potential problem (5). Management of perforation during endoscopic procedures appears to be an ideal target for creating a specific management pathway, because it occurs relatively infrequently, it requires coordination among multiple providers from different services, and a timely implementation of various diagnostics and therapeutic interventions has the potential to directly affect patient care. Our management algorithm incorporates the available scientific literature but also takes into account our local resources. We believe that the process by which we created this algorithm can be used as a model in creating similar management algorithms in other institutions.

In conclusion, clinical pathways are accepted tools to coordinate patient management and increase the environment of safety and communication among health-care providers. Endoscopic perforations appear to be an ideal target for the implementation of such a management algorithm. Future research will need to examine whether the implementation of such algorithms translates into improved clinical outcomes.

CONFLICT OF INTEREST

Guarantor of the article: Peter V. Draganov, MD.
Specific author contributions: Lukasz Kowalczyk: planning of study, drafting of manuscript. Chris E. Forsmark: gastroenterology advisor to paper; editing and review. Kfir Ben-David: surgical advisor to paper; editing and review. Mihir S. Wagh: gastroenterology advisor to paper; editing and review. Shailendra Chauhan: gastroenterology advisor to paper; editing and review. Dennis Collins: gastroenterology advisor to paper; editing and review. Peter V. Draganov: planning of study, oversight over final manuscript submission. All authors approved the final draft for submission.
Financial support: None.
Potential competing interests: None.

REFERENCES

1. Samson R, Berg M, Berg R. Cardiopulmonary resuscitation algorithms, defibrillation and optimized ventilation during resuscitation. Curr Opin Anaesthesiol 2006;19:146–56.
2. Agrawal P, Kosowsky JM. Clinical practice guidelines in the emergency department. Emerg Med Clin North Am 2009;27:555–67.
3. Horwitz LI, Moin T, Green ML. Development and implementation of an oral sign-out skills curriculum. J Gen Intern Med 2007;22:1470–4.
4. Horwitz LI, Moin T, Krumholz HM *et al.* What are covering doctors told about their patients? Analysis of sign-out among internal medicine house staff. Qual Saf Health Care 2009;18:248–55.
5. Malter L, Weinshel E. Improving handoff communication: a gastroenterology fellowship performance improvement project. Am J Gastroenterol 2010;105:490–2.
6. Arora V, Johnson J, Lovinger D *et al.* Communication failures in patient sign-out and suggestions for improvement: a critical incident analysis. Qual Saf Health Care 2005;14:401–7.
7. Sundstrom E, Meuse KE, Futrell D *et al.* Work teams. Am Psychol 1990;45:120–33.
8. Grote G, Zala-Mezö E. Effects of standardization on team coordination: cockpit versus emergency room. HCI-02 Proc 2002;207–9.
9. Sexton JB, Makary MA, Tersigni AR *et al.* Teamwork in the operating room: frontline perspectives among hospitals and operating room personnel. Anesthesiology 2006;105:877–84.
10. Manser T. Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. Acta Anaesthesiol Scand 2009;53:143–51.
11. The Joint Commission. Safety and Communication 2009;1–44. http://www.jointcomission.org